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XMM-Newton and Chandra view of the Cluster Abell 85 and its X-Ray Filament

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Abstract. From ROSAT data, the bright X-ray cluster Abell 85 was found to show a roughly symmetrical shape, on to which are superimposed several features, among which: (1) a blob or group of galaxies falling on to the main cluster, with the gas in the impact region probably hotter and the galaxies in that zone showing enhanced star formation; (2) a filament, either diffuse or made of small groups of galaxies, extending at least 4 Mpc from the cluster (Durret et al. 1998). Preliminary results obtained from XMM-Newton and Chandra observations of Abell 85 and its filament will be presented.

1. Introduction

The hot ($1 \lesssim T \lesssim 10\,\mathrm{keV}$; central density, $n_0 \approx 10^{-3}\mathrm{cm}^{-3}$) X-ray emitting gas found in rich clusters of galaxies is an excellent tool to probe the cluster dynamics, morphology, and history.

We present here an X-ray study of Abell 85 ($z = 0.0556$, richness class $R = 0$, B-M type III) using new XMM-Newton data obtained in January 2002 and public data available from the Chandra archive.

At the distance of Abell 85, 1 arcmin corresponds to $65h_{70}^{-1}$kpc (assuming $\Omega_M = 0.3$ and $\Omega_\Lambda = 0.7$).

2. The Data

Abell 85 was observed in august 2001 by the Chandra satellite (P.I. C. Sarazin) with the ACIS-I detector. The net exposure time was 38.9 ks. Figure 1 shows the Chandra X-ray image and the Chandra isocontours superimposed on a DSS optical image. Notice the irregular form of the South Blob and the excess X-ray emission at the south-west of the main structure.

The two XMM-Newton observations were performed on January 7th, 2002 (P.I. F. Durret). The two exposures were centered on the centre of Abell 85 (coincident with the cD galaxy) and on the south filament respectively. Both exposure times were 12.0 ks.

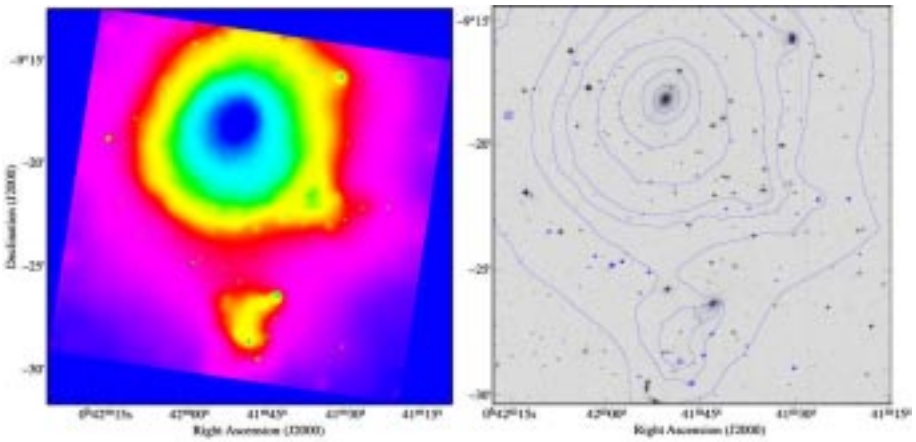

Figure 1. Left: Flux-corrected, adaptatively smoothed X-ray image obtained with Chandra ACIS-I in the broad band [0.3–7.0] keV. Right: X-ray isocontours superimposed on a DSS image.

3. The Centre, the South Blob and the Filament

The left panel of Figure 2 shows a close-up of the central region seen by Chandra. About 15 arcsec southward of the central X-ray maximum there seems to be a "hole" or "bubble" in the X-ray emissivity. There is also a small X-ray point source (which is associated with an optical counterpart) just a few arcsecs to the east of this "hole". Such a "hole" may be produced by the relativistic jets (cf. Ensslin et al 1998) either from the central dominant galaxy or from the object associated with the X-ray point source. Some hot bubbles have been observed in a number of clusters (Mazzotta et al. 2002a,b; Soker et al. 2002).

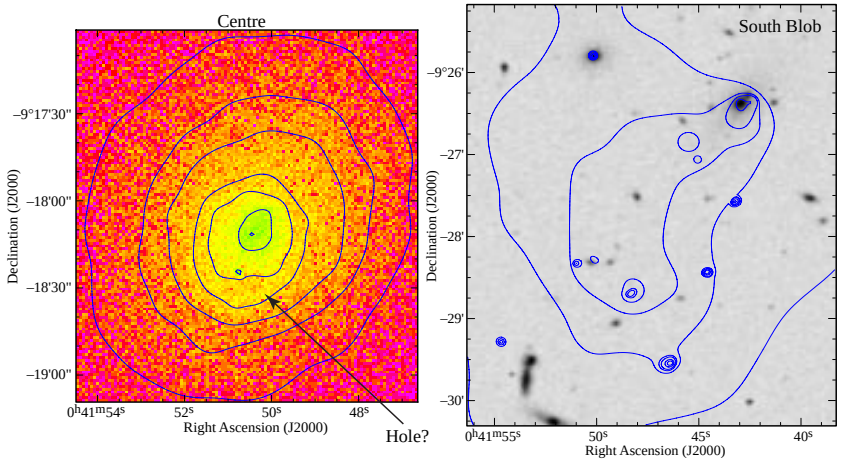

Figure 2. Left: Zoom of the central region seen by Chandra ACIS-I. Right: The South Blob. DSS optical image superimposed with adaptatively smoothed Chandra ACIS-I X-ray iso-contours. Notice that the scales are different.

The South Blob (the second brightest diffuse sub-structure) is shown in the right panel of Figure 2. Notice that it is a highly irregular sub-structure, with the X-ray emission dominated by a point source (a bright galaxy at the redshift of the cluster, see also Lima Neto et al. 1997).

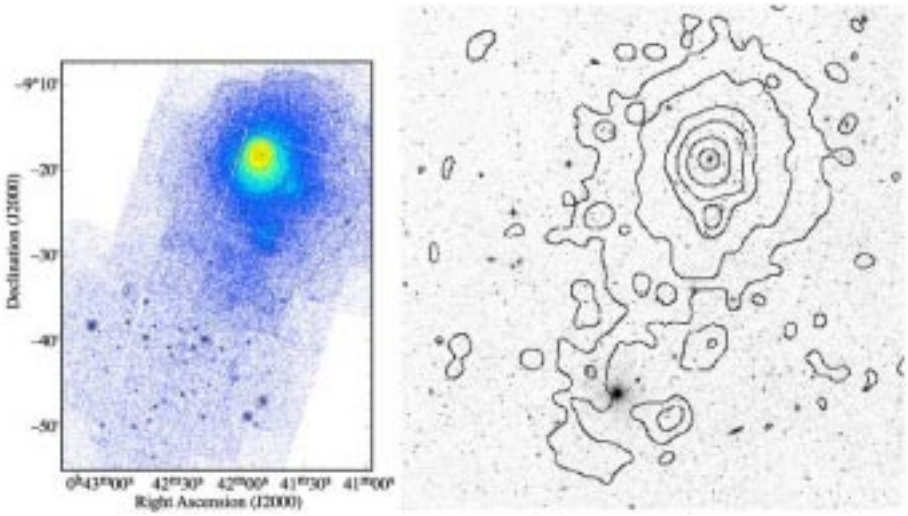

Figure 3. Left: XMM-Newton EPIC MOS 1 and 2 mosaic image showing the central part of Abell 85 and its filament south of the cluster. Right: DSS image on to which are superimposed the smoothed ROSAT PSPC contours showing for the first time the X-ray filament of Abell 85 (Durret et al. 1998).

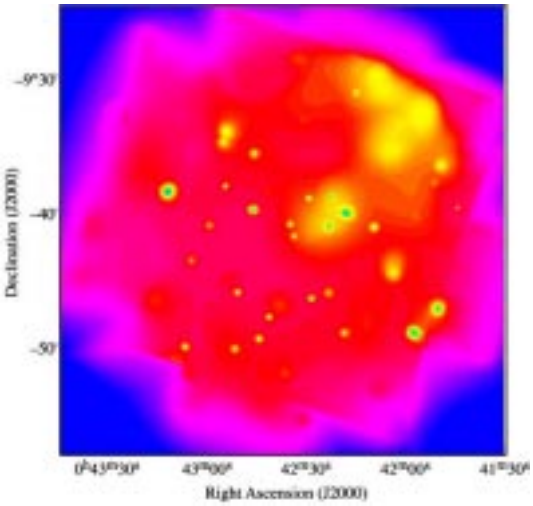

Figure 4. Close-up of Abell 85 filament. This is an adaptatively smoothed XMM image combining the MOS and PN detectors.

Figure 3 shows the mosaic XMM image obtained after combining both observations. The images are the merged data from EPIC-MOS 1 and 2 in the [0.3–8.0] keV band. It is clear that Abell 85 has a diffuse emission extending southward; we interpret this as part of a filament. Figure 4 shows a zoom of the filament region. Filaments are expected to connect cluster in the hierarchical scenario of large scale structure formation (e.g. Jenkins et al. 1998).

4. Temperature and Metallicity Maps

We have computed the temperature and metallicity maps from Chandra data by dividing the central region of Abell 85 into a mesh and, for each cell, fitting an absorbed MEKAL plasma model (Kaastra & Mewe 1993; Liedahl et al. 1995).

Figure 5 shows the temperature and metallicity maps. The X-ray isocontours are overlaid on each map. The cluster is found to be cooler in the central regions where the metallicity is higher.

5. Radial profiles

Figure 6 shows the radial profiles of temperature and metal abundance computed in circular rings around the cluster centre. Notice that there is a significant difference when we fix or not the absorbing hydrogen column density. When fixed, we used the galactic value given by Dickey & Lockman (1990), available with the FTOOLS package.

We compare these profiles to those obtained by Lima Neto et al. (2001) using BeppoSAX data. With the low resolution of BeppoSAX, the central region profile is not adequately determined. With Chandra ACIS-I, there is a clear temperature drop towards the centre.

We also observe a steep rise in the metallicity towards the centre.

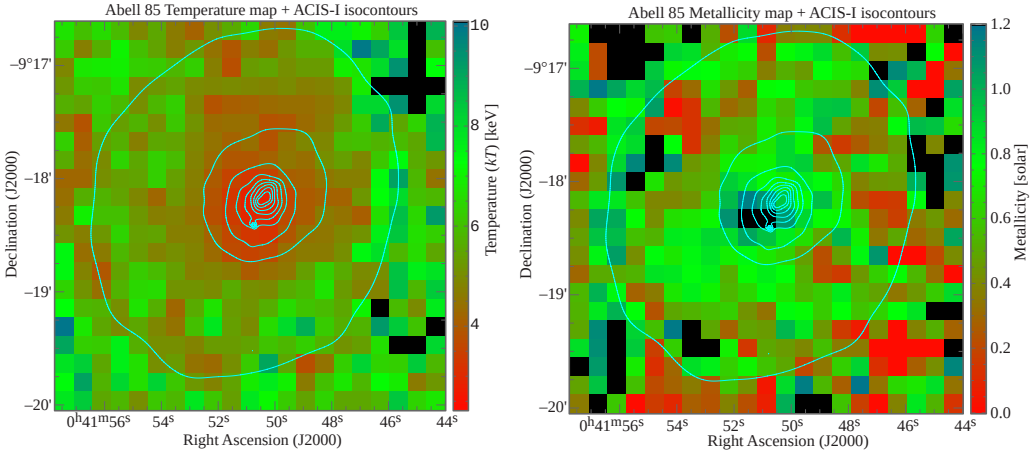

Figure 5. Left: Temperature map of Abell 85 central region. The X-ray isocontours are superimposed. Right: Metallicity map of the same region.

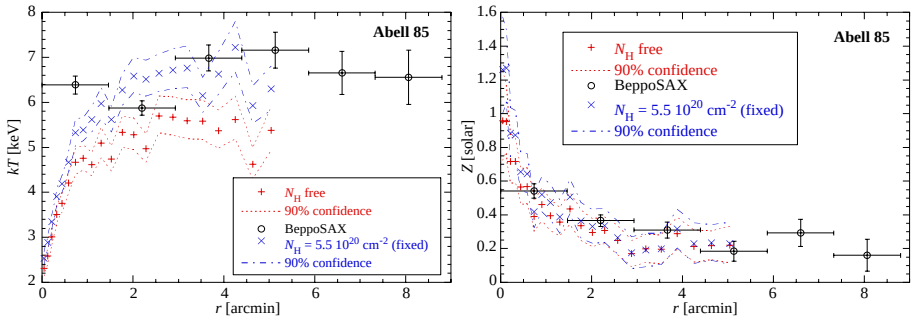

Figure 6. Left: temperature profile. Right: metallicity profile. In both cases, the fits were done with both fixing the hydrogen column density to the galactic value and leaving it as a free parameter.

6. Conclusions

The high resolution and sensibility of XMM-Newton and Chandra satellite provides us with a new vision of an old cluster (quoting a meeting in Marseille five years ago...):

- The X-ray emission in the central region is not totally homogeneous or symmetric: the maximum is displaced relatively to the outer isophotes, a "hole" seems to exist south of the center;
- The temperature is cooler and the metallicity is higher in the central regions of the cluster than was previous measured;
- The existence of an X-ray filament, or at least diffuse X-ray emission south east of the cluster is confirmed; The south blob is definitely not a relaxed structure.

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